Lecture 07

Insights 01 :

Method	Pros	Cons
Spray-Coating	- Suitable for large, irregular substrates	- Lower uniformity
	- Reduced material waste	- Requires precise control
	- Versatile	- Potential for particle defects
Dip-Coating	- Simple, minimal equipment	- Slower process
	- Effective for non-planar surfaces	- Surface tension issues
	- Low material waste	- Limited scalability
Inkjet Printing	- Low material waste	- Limited resolution
	- Customizable patterns	- Slower throughput
	- Suitable for prototyping	- Complex process control
Ultrasonic Coating	- High precision for thin films	- High-cost equipment
	- Low material waste	- Slower process
	- Effective on sensitive and complex surfaces	- Requires precise tuning of parameters

Insight -02:
substrates other than quartz and glass are used in subtraction processes (etching or patterning) in semiconductor and MEMS applications:

1. Silicon (Si)
- **Widely Used:** Common in electronics and photonics for microelectronics fabrication.
- **Processes:** Wet etching, dry etching (RIE).

2. Polymers (e.g., PMMA, SU-8)
- **Flexible Substrates:** Used for flexible electronics and sensors.
- **Processes:** UV lithography, plasma etching.

3. Sapphire (Al_2O_3)
- **Durable and Transparent:** Used in optoelectronics.
- **Processes:** Dry etching, ion milling.

4. GaAs (Gallium Arsenide)
- **High-Speed Devices:** Popular in RF applications.
- **Processes:** Wet etching, plasma etching.

Insight -03:

1nm to 2mm range. Here's an integrated summary:

1 nm - 10 nm (Nanoscale):

1. **CPUs (Central Processing Units)**:
   - Modern CPUs utilize transistors with gate lengths as small as **5-10 nm**, leveraging advancements in semiconductor technology, particularly in **2 nm process nodes** developed by companies like **Samsung and TSMC**. This enables greater computational efficiency, power savings, and faster processing.
2. **NAND Flash Memory**:
   - Flash memory cells, particularly **NAND**, operate within the **1-10 nm** range, offering high-density data storage for devices such as **SSDs, smartphones, and laptops**.

100 µm - 2 mm (Microscale):

1. **Micro-Electro-Mechanical Systems (MEMS)**:
    - MEMS devices, such as **accelerometers, gyroscopes, and microphones**, function in the **100 µm to 2 mm** range. These components are crucial for applications in **motion sensing, navigation, and audio processing**, and are commonly found in **smartphones, automotive systems, and medical devices**.
2. **Light-Emitting Diodes (LEDs)**:
    - High-power **LEDs** have chip sizes around **1-2 mm**, widely used in applications such as **lighting, automotive headlights**, and **display backlighting**

Insight 04:

Anisotropic etching is widely used in MEMS for creating three-dimensional microstructures. The process selectively removes material based on crystallographic orientation, making it ideal for constructing complex features with high precision. By carefully controlling the etching conditions, vertical and sloped walls, cavities, and suspended elements can be formed, essential in the fabrication of devices such as accelerometers, pressure sensors, and AFM probes. This method is predominantly applied to silicon substrates but has been adapted for other materials. Common applications include sensor structures, actuators, and other microscale mechanical systems.

Anisotropic undercut occurs in anisotropic etching due to the differences in etch rates along various crystallographic orientations of a material, such as silicon. In anisotropic etching, certain crystal planes (e.g., the {111} planes in silicon) are etched more slowly than others (e.g., the {100} planes).

Why it happens:

- The etch process progresses faster along some crystal planes and slower along others, causing the material to undercut in regions where the slow-etching planes are exposed.
- **Undercutting** occurs because etching does not proceed vertically at the same rate along all directions, resulting in the formation of angled sidewalls and recessed areas beneath mask layers.

Applications of Anisotropic Undercut:

- **Microchannels and Cavities**: In MEMS, anisotropic undercutting is essential for creating precise microchannels and cavities, which are used in fluidic devices and sensors.
- **Suspended Structures**: Undercutting is also leveraged to create suspended structures, such as cantilevers or bridges, used in devices like micro switches and pressure sensors.
- **Sharp Edge Definition**: It allows for the creation of sharp, well-defined edges critical for various micro-mechanical systems.

Rephrase for Research Paper Abstract:

This paper gives an overview discusses bio-mimicking techniques that can replicate natural material characteristics in synthetic ones, particularly in the medical industry. It covers common methods for creating micro- or nano-patterned polymer substrates, highlighting their benefits in the biomedical field. Techniques like photolithography, electron beam, and soft lithography are explored, as well as alternative methods involving biomolecule crystallization and DNA self-assembly. These patterned substrates have applications in studying cell interactions, development, and migration, especially concerning blood cells and disorders.

Finally, the review summarizes the advantages of using such substrates in biosensing devices for medical diagnostics and healthcare.